Appendix C-2

Watercraft Electrical Safe Design, Reliability, and Maintainability Checklist Design Options that Reduce the Likelihood of Injury from Electrical Hazards including Shock, Arc Flash and Fire

Purpose: This checklist identifies available design technologies which can reduce the likelihood or limit the severity of electric shock, arc flash and electrical fires aboard watercraft including ships, submarines, and other marine vessels. These technologies provide opportunities for application beyond the minimum requirements and electrical design standards. Each technology must be assessed for its intended application and may have some disadvantages along with advantages. As with any design, an engineering analysis should be performed to determine the best type of equipment for the situation.

Requirements: OSHA 29 CFR 1915.181 which apply to ship repair and ship building, 46 CFR Chapter I, Subchapter J, *Electrical Engineering (*US Coast Guard*)*, National Fire Protection Association (NFPA) 70, the National Electric Code (NEC) for docks and shore-based electrical systems, Naval Ships' Technical Manual (NSTM) 300, *Electrical Plant - General*, NSTM 302, Electric Motors and Controllers, MIL-HDBK-454 Rev. B or latest version, *Department Of Defense Handbook: General Guidelines For Electronic Equipment*; DA Pam 385-26: The Army Electrical Safety Program.

Applicability: This checklist is a tool to aid the planner, designer, and safety professional to maximize the quality of watercraft electrical safe designs. It is intended for use by DoD services, agencies, and contractors involved with watercraft.

DOCUMENT CHANGE TABLE			
DATE	AUTHOR	CHANGES MADE	VERSION

Watercraft Electrical Safe Design, Reliability, and Maintainability Checklist
Design Options that Reduce the Likelihood of Injury from Electrical Hazards including Shock, Arc Flash and Fire

Date of Inspection: _____
Inspector Name: _____
Reviewer Position: _____
Email: _____
Phone #: _____

The following technologies can reduce the likelihood or limit the severity of electric shock, arc flash and electrical fires aboard vessels. An engineering analysis should determine the best type of equipment for the situation.

Number	Item	Y/N/NA
Design and application of coordination of relay and circuit breaker settings; and engineered proper circuit breaker sizing and selection		
1	High resistance grounding.	
2	Covered or isolated bus.	
3	Current-limiting fuses and current limiting breakers.	
4	Touch-proof equipment.	
5	Arc-resistant enclosures and arc resistant switchgear.	
6	Remote operation of equipment and use of “Smart” control centers.	
7	Arc detection and suppression systems.	
8	Ground fault detection.	
9	Arc fault circuit interrupters.	
10	Inspection ports for switchgear and power distribution equipment.	
11	Isolation transformers for shore power circuits.	
12	Arc flash reduction maintenance system.	
NOTE	Isolation transformers prevent galvanic corrosion and the hazard of electric shock caused by reverse polarity dockside.	

Number	Item	Y/N/NA
General Provisions For New Vessels - Inspections		
13	Initial written record of inspection certification completed during construction of the vessel which includes a complete inspection of the electric installation and electric equipment or apparatus. The inspection is to determine that the arrangement, materials, and their installations meet the approved plans.	
14	Periodic inspections to determine mechanical and electrical condition and performance.	
15	Have there been any circuits added or modified after the original issuance of the Certificate of Inspection?	
NOTE	The Officer in Charge of marine inspection must be notified before alterations or modifications occur that deviate from approved plans or repairs, and any alternations or modifications that affect the electrical systems of the vessel.	
Arrangement of Equipment, Equipment Design, Protection, Access and Spacing		
16	Electric equipment arranged to prevent mechanical damage to the equipment from the accumulation of dust, oil mists or vapors, steam, or dripping liquids.	
17	Apparatus that may arc are ventilated or are in ventilated compartments in which flammable gases, acid fumes, and oil vapors cannot accumulate.	
18	Bilge area arranged or constructed so the following cannot be damaged by bilge water: (a) Generators. (b) Motors. (c) Electric coupling. (d) Electric cable.	
19	Design and arrangement of all electric apparatus is accessible to facilitate inspection, adjustment, maintenance, or replacement.	
20	The spacing between energized components (or between an energized component and ground) within an enclosure meet the appropriate industry standard for the voltage and current utilized in the circuit.	
21	Spacing within enclosure(s) sufficient to facilitate servicing.	
NOTE	The width of the working space must be a minimum of 30 inches. Refer to National Electric Code Article 110.26 for working space around enclosures and equipment. Also, see: http://www.usbr.gov/ssle/safety/RSHS/sec12.pdf.	

Number	Item	Y/N/NA
22	All electrical enclosures are according to NEMA 250 or IEC 60529, both incorporated by reference (see 46 CFR 110.10-1) to provide protection against environmental conditions.	
NOTE 1	The word “should,” when used in material incorporated by reference is to be construed the same as the words “must” or “shall”. Web link for 46 CFR 110.10-1: http://cfr.regstoday.com/46cfr110.aspx#46_CFR_110pSUBPART_110p10.	
NOTE 2	NEMA Type 2 enclosures are constructed to provide a degree of protection to personnel against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (falling dirt); and to provide a degree of protection with respect to harmful effects on the equipment due to the ingress of water (dripping and light splashing). NEMA Type 4 enclosures provide protection from windblown rain, splashing water and are undamaged from the formation of ice on the enclosure. Type 4X also provides protection against corrosion.	
23	Electrical equipment in locations requiring exceptional degrees of protection meet at least the minimum degrees of protection in ABS Steel Vessel Rules section 4-8-3, Table 2, or appropriate NEMA 250 type for the service intended	
24	Each enclosure is designed so that the total rated temperature of the equipment inside the enclosure is not exceeded.	
25	Central control consoles and similar control enclosures are manufactured to at least NEMA 250 Type 2 or IEC 60529 IP 22 degree of protection regardless of location.	
26	Equipment for interior locations not requiring exceptional degrees of protection is manufactured to at least NEMA 250 Type 1 with drip-shield or IEC 60529 IP 11 as specified in IEC 60529.	
27	Each enclosure and part of electric equipment that can be damaged by corrosion is be made of corrosion-resistant materials or of materials having a corrosion resistant finish.	

Number	Item	Y/N/NA
Equipment Operation and Installation		
28	The assumed ambient temperature of the space plus the equipment's actual temperature rise at its de-rated load does not exceed the equipment's total rated temperature (equipment's rated ambient temperature plus its rated temperature rise).	
29	Electrical equipment functions at variations of at least ±5 percent of rated frequency and 6 percent to 10 percent of rated voltage. This limitation does not address transient conditions.	
30	All electrical equipment is designed and installed to operate for the particular location and environment in which it is to be used.	
31	Electric apparatus is designed, constructed and installed with guarding to prevent any person from accidentally contacting energized parts.	
32	Any exposed, noncurrent-carrying metal parts of fixed equipment that may become energized because of any condition is grounded.	
Grounding Design		
33	Exposed, noncurrent-carrying metal parts of portable equipment are grounded through a conductor in the supply cable to the grounding pole in the receptacle.	
34	For the installation of the electrical equipment which does not ensure a positive ground to the metal hull or equivalent conducting body, the apparatus is grounded to the hull with a grounding conductor.	
35	When installed, the metallic armor or sheath meets the installation requirements of Section 25 of IEEE 45.	
NOTE	IEEE 45 has eight sections which are recommendations for the minimally acceptable guidelines for the design, selection, and installation of systems and equipment aboard marine vessels applying electrical apparatus for power, propulsion, steering, navigation, lighting, and communications.	
36	A vessel's hull does not carry current as a conductor except for the following systems: (1) Impressed current cathodic protection systems. (2) Limited and locally grounded systems, such as a battery system for engine starting that has a one-wire system and the ground lead connected to the engine. (3) Insulation level monitoring devices if the circulation current does not exceed 30 milli-amperes under the most unfavorable conditions. (4) Welding systems with hull return except vessels subject to 46 CFR Subchapter D.	

Number	Item	Y/N/NA
NOTE	46 CFR Subchapter D only applies to tank vessels which carry flammable or combustible liquids in bulk.	
37	Each grounded system has only one point of connection to ground regardless of the number of power sources operating in parallel in the system.	
38	Each propulsion, power, lighting, or distribution system having a neutral bus or conductor has the neutral grounded.	
39	The neutral of a dual-voltage system is solidly grounded at the generator switchboard.	
40	The neutral of each grounded generation and distribution system is grounded at the generator switchboard, except the neutral of an emergency power generation system which must be grounded with no direct ground connection at the emergency switchboard	
41	The neutral of each grounded generation and distribution system is grounded at the generator switchboard, except the neutral of an emergency power generation system which must be grounded with: No switch, circuit breaker, or fuse in the neutral conductor of the bus-tie feeder connecting the emergency switchboard to the main switchboard; and have the ground connection accessible for checking the insulation resistance of the generator to ground before the generator is connected to the bus.	
42	If the voltage of a distribution system is less than 1,000 volts, line to line, a tank vessel has a grounded distribution system.	
43	If the voltage of a distribution system on a tank vessel is 1,000 volts or greater, line to line, and the distribution system is grounded (including high-impedance grounding), any resulting current must not flow through a hazardous (classified) location.	
44	There is ground detection for: 1) Electric propulsion system; 2) Vessel's service power system; 3) Lighting system; and 4) Power or lighting distribution system that is isolated from the vessel's service power and lighting system by transformers, motor generator sets or other devices.	
45	Ground indicators are readily accessible.	

Number	Item	Y/N/NA
46	Ground indicators are provided (at the distribution switchboard or at another location, such as a centralized monitoring position for the circuit affected) for each feeder circuit that is isolated from the main source by a transformer or other device.	
47	Each ungrounded system is provided with a suitably sensitive ground detection system located at the respective switchboard which provides continuous indication of circuit status to ground with a provision to momentarily remove the indicating device from the reference ground.	
48	Grounded neutral and high-impedance grounded neutral alternating current systems has a suitably sensitive ground detection system which indicates current in the ground connection, is able to withstand the maximum available fault current without damage, and provides continuous indication of circuit status to ground.	
49	Provision is included to compare indications under fault conditions with those under normal conditions.	
50	Each dual voltage direct current system has a suitably sensitive ground detection system which indicates current in the ground connection, has a range of at least 150 percent of neutral current rating and indicates the polarity of the fault	
51	A conductor for grounding a direct-current system is the larger of the largest conductor supplying the system; or No. 8 AWG (8.4mm^2).	
52	A conductor for grounding the neutral of an alternating-current system meets 46 CFR Table 111.05-31(b).	
NOTE	Web link for 46 CFR Ch. I, Table 111.05-31(b): http://www.gpo.gov/fdsys/pkg/CFR-2009-title46-vol4/pdf/CFR-2009-title46-vol4-sec111-05-23.pdf	
53	Each equipment-grounding conductor (other than a system-grounding conductor) of a cable must be permanently identified as a grounding conductor in accordance with the requirements of the NEC Section 250.119.	
54	A permanently grounded conductor must not have an overcurrent device unless the overcurrent device simultaneously opens each ungrounded conductor of the circuit.	
55	The neutral conductor of the emergency-main switchboard bus-tie must not have a switch or circuit breaker.	

Number	Item	Y/N/NA
NOTE	Service loads mean electrical equipment for all auxiliary services necessary for maintaining the vessel in a normal, operational and habitable condition. Ship's service loads include, but are not limited to, all safety, lighting, ventilation, navigational, communications, habitability, and propulsion auxiliary loads.	
Vessel Power Supply Design and Operation		
56	Each self-propelled vessel has at least two electric generating sources.	
57	The aggregate capacity of the electric vessel's service generating sources is sufficient for the vessel's service loads.	
58	Failure of any single generating set energy source such as a boiler, diesel, gas turbine, or steam turbine does not cause all to be inoperable generating sets.	
59	If the emergency generator is used for part or all of the electric power necessary to start the main propulsion plant from a dead ship condition, the emergency generator is capable of providing power to all emergency lighting, emergency internal communications systems, and fire detection and alarm systems in addition to the power utilized for starting the main propulsion plant.	
60	Each generator prime mover must have an overspeed device that is independent of the normal operating governor and adjusted so that the speed cannot exceed the maximum rated speed by more than 15 percent.	
61	Each prime mover must shut down automatically upon loss of lubricating pressure to the generator bearings if the generator is directly coupled to the engine. If the generator is operating from a power take-off, such as a shaft driven generator on a main propulsion engine, the generator (must) automatically declutch (disconnect) from the prime mover upon loss of lubricating pressure to generator bearings.	
62	Each generator meets the applicable requirements for construction and testing in section 4-8-3 of the ABS Steel Vessel incorporated by reference; see 46 CFR Rules 110.10-1.	
63	For AC systems compliance with sections 4-2-3/7.5.2, 4-2-4/7.5.2, 4-8-3/3.13.2, and 4-8-3/3.13.3 of the ABS Steel Vessel Rules.	
64	For DC systems: section 4-8-3/3.13.3(c) of the ABS Steel Vessel Rules, and IEC 60092-202: *System Design – Protection Part 202*; and IEC 60092-301: *Electrical Installations in Ships, Part 301, Equipment – Generators and Motors*.	
65	The current-carrying capacity of generator cables is not less than 115 percent of the continuous generator rating; or Less than 115 percent of the overload for a machine with a 2 hour or greater overload rating.	

66	Generator cables are not in the bilges.	
Number	**Item**	**Y/N/NA**
67	Each vessel's service generator and emergency generator is protected by an individual, trip-free, air circuit breaker whose tripping characteristics can be set or adjusted to closely match the generator capabilities.	
68	A circuit breaker for a generator opens upon the shutting down of the prime mover.	
69	A circuit breaker for a generator has longtime overcurrent trips or relays set as necessary to coordinate with the trip settings of the feeder circuit breakers.	
70	A circuit breaker for a generator does not have an instantaneous trip with the exception that an instantaneous trip is required if three or more alternating-current generators can be paralleled; or the circuit breaker is for a direct current generator.	
71	The pickup setting of the longtime overcurrent trip of a generator circuit breaker is not larger than 115 percent of the generator rating for a continuous rated machine.	
72	The pickup setting of the longtime overcurrent trip of a generator circuit breaker is not larger than 115 percent of the overload rating for a machine with a 2-hour or greater overload rating.	
73	The instantaneous trip of a generator circuit breaker is set above, but as close as practicable to, the maximum asymmetrical short circuit available from any one of the generators that can be paralleled.	
74	Each generator arranged for parallel operation has reverse-power or reverse-current trips.	
75	A vessel’s service generator overcurrent protective device is on the vessel's service generator switchboard.	
76	The generator and its switchboard are in the same space.	
77	There is separate circuit breaker poles for the positive and negative leads, and, unless the main poles provide protection, for each equalizer lead. If there are equalizer poles for a three-wire generator, each overload trip is of the “Algebraic” type.	
78	If there is a neutral pole in the generator circuit breaker, there is not an overload trip element for the neutral pole. In this case, there must be a neutral overcurrent relay and alarm system that is set to function at a current value not more than the neutral rating.	

Number	Item	Y/N/NA
79	For each three-wire generator, the circuit breaker protects against a short circuit on the equalizer bus.	
80	Generator circuit breakers do not automatically close after tripping.	
Battery Design and Installation		
81	A battery cell, when inclined at 40 degrees from the vertical, does not spill electrolyte.	
82	Each fully charged lead-acid battery has a specific gravity that meets Section 22 of IEEE 45.	
83	Batteries do not evolve hydrogen at a rate exceeding that of a similar size lead-acid battery under similar charging condition.	
84	Battery location and type take into account the environmental conditions of a marine installation, including temperature, vibration, and shock.	
85	Each large battery installation is in a room that is only for batteries or a box on deck. Installed electrical equipment must meet the hazardous location requirements.	
86	Each moderate battery installation is in a battery room, in a box on deck, or in a box or locker in another space such as an engine room, storeroom, or similar space, except if a moderate battery installation is in a ventilated compartment such as the engine room and is protected from falling objects, a box or locker is not required.	
87	A moderate battery installation is not in a sleeping space. An engine cranking battery for one or more engines is as close as possible to the engine or engines.	
88	Small size battery installations are not located in poorly-ventilated spaces, such as closets, or in living spaces, such as staterooms.	
NOTE 1	A small battery installation is one connected to a battery charger that has an output of less than 0.2 kw computed from the highest possible charging current and the rated voltage of the battery installation.	
NOTE 2	A moderate battery installation is one connected to a battery charger that has an output of between 0.2 kw and 2 kw computed from the highest possible charging current and the rated voltage of the battery installation.	

Number	Item	Y/N/NA
NOTE 3	A large battery installation is one connected to a battery charger that has an output of more than 2 kw computed from the highest possible charging current and the rated voltage of the battery installation.	
89	Each battery tray is chocked with wood strips or their equivalent to prevent movement, and each tray must has non-absorbent insulating supports on the bottom and similar spacer blocks at the sides, or equivalent provisions for air circulation space all around each tray.	
90	Each battery tray provides adequate accessibility for installation, maintenance and removal of the batteries.	
91	Each room, locker and box for storage batteries is arranged or ventilated to prevent accumulation of flammable hydrogen gas.	
92	If power ventilation is required, the following must be met: The power ventilation system must be separate from ventilation systems for other spaces. Electric motors must be outside the duct and compartment and have an explosion-proof motor for a Class I, Division 1, Group B location; or at least 10 ft. (3 m) from the exhaust end of the duct.	
93	Each blower for battery location ventilation has a non-sparking fan.	
94	The power ventilation system is interlocked with the battery charger so that the battery cannot be charged without adequate ventilation.	
95	Each battery room for large battery installations has a power exhaust ventilation system and openings for intake air near the floor that allow the passage of the quantity of air that must be expelled.	
96	The quantity of the air expelled is at least q =3.89(i)(n); where q is the quantity of expelled air in cubic feet per hour; i is the maximum charging current, or one-fourth of the maximum obtainable charging current of the charging facility, whichever is greater; and n = number of cells.	
97	Each box for a small battery installation has openings near the top to allow the escape of gas. If the installation is in a non-environmentally-controlled location, the installation prevents the ingress of water.	
98	Each battery room or battery locker for moderate or small battery installations have louvers near the bottom of the room or locker for air with forced air ventilation.	
99	Except for a deck box for a small battery installation, each deck box has a duct from the top of the box to at least 4 ft. (1.2 m) above the box ending in a gooseneck or mushroom head that prevents entrance of water. Holes for air must be on at least two parallel sides of each box.	

Number	Item	Y/N/NA
100	Each deck box is weather-tight.	
101	Each box for a small battery installation must have openings near the top to allow escape of gas. If the installation is in a non-environmentally-controlled location, the installation must prevent the ingress of water.	
102	Each conductor penetration to a battery room is watertight.	
103	The termination of each cable is sealed to prevent the entrance of electrolyte by spray or infiltration.	
104	Each connecting cable has sufficient capacity to carry the maximum charging current or maximum discharge current, whichever is greater, while maintaining the proper voltage at the load end.	
105	An overload protective device must be in each battery conductor, except conductors of engine cranking batteries and batteries with a nominal potential of 6 volts or less.	
106	For large storage battery installations, the overcurrent protective devices must be next to, but outside of, the battery room.	
107	Except when a rectifier is used, the charging equipment for all batteries with a nominal voltage more than 20 percent of line voltage must protect automatically against reversal of current.	
108	Each battery charger is suitable for the size and type of battery installation that it serves. Chargers incorporating grounded autotransformers must not be used. Except for rectifiers, chargers with a voltage exceeding 20 percent of the line voltage must be provided with automatic protection against reversal of current.	
Transformer Construction, Installation and Protection		
109	Each transformer winding is resistant to moisture, sea atmosphere and oil vapor, unless special precautions are taken such as enclosing the winding in an enclosure with a high degree of ingress protection.	
110	Transformer temperature rise, based on an ambient temperature of 40 degrees C, must not exceed 55 degrees C for Class A insulation; for Class B insulation, 80 degrees C; for Class F insulation, 115 degrees C; for Class H insulation, 150 degrees C.	
NOTE	Electrical insulation systems for wires used in transformers (electric motors and generators) are rated by NEMA classifications to maximum allowable operating temperatures.	

Number	Item	Y/N/NA
111	An autotransformer must not supply feeders or branch circuits.	
112	Transformer has protection against overcurrent that meets Article 450 of the NEC or IEC 60092-303, *Electrical Installations in Ships – Transformers for Power and Lighting.*	
NOTE	NEC Article 450 provides requirements for transformers and transformer vaults.	
Electric Motors		
113	Each motor has a marking or nameplate that meets either NEC Section 430.7 or clause 16 of IEC 60092-301, *Equipment - Generators and Motors*.	
114	Each motor is rated for continuous duty, except a motor for an application listed in 46 CFR Chapter I, Subpart J, Table 111.25-15 or a similar duty must meet the minimum short-time rating stated in the table.	
NOTE	From IEEE 45-2002: Generators and motors should successfully pass the following tests at the place of manufacture. The following tests should be conducted in accordance with IEC60034, or IEEE Std 112, IEEE Std 115, or ANSI/NEMA MG 1-1998, as applicable: a) Temperature rise under rated load or rated current conditions; b) Dielectric strength of insulation; c) Overload capacity.	
Switchboard Installation and Design		
115	Each switchboard meets the location and installation requirements in section 8.2 of IEEE 45 or IEC 60092-302.	
116	Each component and bus bar connection on a switchboard that is not accessible from the rear, except a bus bar connection for a draw-out type circuit breaker is within 0.5 m (20 in.) of the front of the switchboard.	
117	Circuit breakers, when installed on generator or distribution switchboards, are mounted or arranged in such a manner that the circuit breaker may be removed from the front without unbolting bus or cable connections or de-energizing the supply, unless the switchboard is divided into sections, such that each section is capable of providing power to maintain the vessel in a navigable condition.	
118	All low voltage switchboards meet either section 8.3 of IEEE 45 or IEC 60092-302.	

Number	Item	Y/N/NA
119	Medium voltages meet either section 8.4 of IEEE 45 or IEC 60092-503: *Electrical Installations in Ships, Part 503*.	
120	Non-conducting deck coverings, such as non-conducting mats or gratings, suitable for the specific switchboard voltage are installed for personnel protection at the front and rear of the switchboard and extend the entire length of, and be of sufficient width to suit the operating space.	
121	Each switchboard device has a nameplate showing its function.	
122	Each nameplate for a circuit breaker shows the electrical load served and the setting of the circuit breaker.	
123	Each circuit that supplies a device on a switchboard has overcurrent protection <u>except</u> as indicated in the four below:	
124	1) A circuit that supplies a device on a switchboard does not have overload protection if it supplies an electric propulsion control.	
125	2) A circuit that supplies a device on a switchboard does not have overload protection if it supplies a voltage regulator.	
126	3) A circuit that supplies a device on a switchboard does not have overload protection if it supplies a ship's service generator circuit breaker tripping control.	
127	4) A circuit that supplies a device on a switchboard does not have overload protection if the device creates a hazard to the vessel if de-energized.	
128	If short circuit protection is used in any of the circuits, it is set at not less than 500% of the expected current.	
129	A secondary circuit of a current transformer is not be fused, and the circuit from a current transformer to a device that is not in the switchboard has a high voltage protector to short the transformer during an open circuit.	
130	Each bus meets the requirements of section 7.10 of IEEE 45; or (clause 7), IEC 60092-302: *Low Voltage Switchgear and Control Gear Assemblies*.	
NOTE	The most recent edition of IEEE 45 should be consulted for requirements.	
131	Instrumentation and control wiring is suitable for installation within in a switchboard enclosure and be rated at 90 °C or higher.	

Number	Item	Y/N/NA
132	Stranded copper is No. 14 AWG (2.10 mm 2) or similar conductor size cable recommended for use in low-power instrumentation, monitoring, or control circuits recommended by the equipment manufacturer.	
133	Stranded copper is flame-retardant meeting test VW-1 of UL 1581 or IEC 332-1.	
134	Stranded copper is extra flexible, if used on a hinged panel.	
135	When the total installed electric power of the vessel's service generation system is more than 3000 kW, the switchboard has at least two sections of the main bus that are connected by a non-automatic circuit breaker; a disconnect switch; or removable links.	
136	As far as practicable, the connection of generators and duplicated equipment is equalized between the sections of the main bus.	
137	For alternating-current ship's service, each switchboard has a disconnect switch or link for each generator conductor, except a switchboard having a draw-out or plug-in type generator circuit breaker that disconnects each generator conductor; or if there is a switch in the generator neutral, each ungrounded conductor.	
138	For each connected generator, each switchboard has a pilot lamp connected between the generator and the circuit breaker.	
139	For each connected generator, each switchboard has an ammeter with a selector switch that connects the ammeter to show the current in each phase.	
140	For each connected generator, each switchboard has a voltmeter with a selector switch that connects the voltmeter to show the generator voltage of each phase; and bus voltage of one phase.	
141	For each connected generator, each switchboard has a voltage regulator and voltage regulator functional cut-out switch.	
142	For each generator that is not excited from a variable voltage or rotary amplifier that is controlled by a voltage regulator unit acting on the exciter field, each switchboard has a generator field rheostat; a double-pole field switch; discharge clips; and a discharge resistor.	
143	If generators are arranged for parallel operation, each switchboard has a speed control for the prime mover of each generator; an indicating wattmeter for each generator; and a synchroscope and synchronizing lamp that have a selector switch to show synchronization for paralleling generators.	

Number	Item	Y/N/NA
144	Each switchboard has ground detection for the vessel's service power system; normal lighting system; and emergency lighting system.	
145	Each switchboard has a frequency meter with a selector switch to connect the meter to each generator.	
146	Each switchboard has an exciter field rheostat.	
147	For each shore power connection each switchboard has a circuit breaker or fused switch; a pilot light connected to the shore side of the circuit breaker or fused switch; and one of the voltmeters connected to show the voltage of each phase of the shore power connection	
148	The equipment, except the circuit breakers and disconnect switch or link for each generator conductor is on the vessel’s service switchboard, or on a central control console that is in the same control area as the main vessel's service switchboard; or can remotely control the vessel service generator circuit breaker.	
149	Equipment, except the circuit breakers and disconnect switch or link for each generator conductor is on the ship's service switchboard, or on a central control console that has a generator section that has only generator functions; has the generator section segregated from each other console section by a fire-resistant barrier; and has cabling from the main switchboard to the generator section of the console that has only generator control and generator instrumentation circuits; and is protected from mechanical damage.	
150	Direct current ship's service: For each connected generator, each switchboard has a circuit breaker disconnect switch or link for each generator conductor, except a switchboard having a draw-out or plug-in type generator circuit breaker that disconnects each conductor; or if there is a switch in the generator neutral, each ungrounded conductor.	
151	For each connected generator, each switchboard has a field rheostat and a pilot lamp connected between the generator and circuit breaker.	
152	For each two-wire generator, each switchboard must have an ammeter; and A voltmeter with a selector switch that connects the voltmeter to show: Generator voltage; and bus voltage.	
153	For each three-wire generator, each switchboard has an ammeter for the positive lead; and the negative lead; a center zero type ammeter for the neutral ground connection; a voltmeter with a selector switch that connects the voltmeter to show generator and bus voltage: positive to negative; positive to neutral; and neutral to negative.	

Number	Item	Y/N/NA
154	Each switchboard has ground detection for the: main power system; main lighting system; and emergency lighting system.	
155	For each shore power connection, each switchboard has a circuit breaker or fused switch; and a pilot light connected to the shore side.	
156	One of the voltmeters is connected to show for each two-wire system, shore connection voltage; and for each three-wire system, shore connection voltage: positive to negative; positive to neutral; and neutral to negative.	
157	Each emergency generator must have an emergency switchboard.	
158	There is a test switch at the emergency switchboard to simulate a failure of the normal power source and cause the emergency loads to be supplied from the emergency power source.	
159	The emergency switchboard is as near as practicable to the emergency power source, but not in the same space as a battery emergency power source.	
160	Each alternating-current emergency switchboard: For each connected emergency generator, each emergency switchboard has a circuit breaker and a disconnect switch or link for each emergency generator conductor, except for a switchboard with a draw out or plug-in type generator circuit breaker that disconnects each generator conductor; and if there is a switch in the generator neutral, each ungrounded conductor; and a pilot lamp connected between the generator and circuit breaker.	
161	For each emergency generator that is not excited from a variable voltage or rotary amplifier exciter that is controlled by a voltage regulator unit acting on the exciter field, each emergency switchboard has a generator field rheostat; a double pole field switch; discharge clips; and a discharge resistor.	
162	Each emergency switchboard has the following: an ammeter with a selector switch that connects the ammeter to show the current for each phase; A voltmeter with a selector switch that connects the voltmeter to show: generator voltage of each phase; and bus voltage of one phase; Ground detection for the emergency lighting system; A frequency meter; An exciter field rheostat; A voltage regulator and a voltage regulator functional cut-out switch.	

Number	Item	Y/N/NA
163	Each direct-current emergency switchboard has ground detection for the emergency lighting system.	
Emergency Lighting and Power Systems		
164	The power from the vessel's service generating plant for the emergency loads is supplied to the emergency switchboard through automatic transfer switches.	
165	If there is a reduction of potential of the normal source by 15 to 40 percent the loads are automatically supplied from the temporary emergency power source.	
166	For systems in which a reduction of frequency of the normal source or final emergency power source adversely affects the emergency system and emergency loads, there is a means to transfer the loads to the temporary emergency power source upon a reduction in the frequency of the normal source or final emergency power source.	
167	Simultaneously with the operation of the transfer means the diesel engine or gas turbine driving the final emergency power source start automatically with no load on the final emergency power source.	
168	When the potential of the final emergency power source reaches 85 to 95 percent of normal value, the emergency loads transfer automatically to the final emergency power source. This transfer should be accomplished in no more than 45 seconds after failure of the normal source of power.	
169	When the potential from the normal source has been restored, the emergency loads are manually or automatically transferred to the normal source, and the final emergency power source is manually or automatically stopped.	
170	If the potential of the final emergency power source is less than 75 to 85 percent of normal value while supplying the emergency loads, the temporary emergency loads transfers automatically to the temporary emergency power source.	
171	Each temporary source of emergency power must consist of a storage battery of sufficient capacity to supply the temporary emergency loads for not less than one-half hour.	

Number	Item	Y/N/NA
172	Installations requiring alternating current for the operation of communication equipment or other apparatus essential under temporary emergency conditions must be provided with the necessary conversion equipment. If the conversion equipment operates both under normal conditions and under temporary emergency conditions, the conversion equipment must be provided in duplicate.	
173	An emergency lighting system does not have a switch, except: In a distribution panel; or in a circuit that serves a hazardous space such as a paint room or cargo handling room if the switch is located outside of the hazardous location.	
174	There are visible indicators in the machinery space showing when an emergency battery is discharging; and when the automatically controlled emergency power source is supplying the emergency loads.	
175	Each storage battery installation for emergency lighting and power, and starting batteries for an emergency diesel or gas turbine driven generator set, have apparatus to automatically maintain the battery fully charged.	
176	When the vessel's service generating plant is available, the battery has a continuous trickle charge, except that after discharge the battery must be charged automatically at a higher rate.	
177	Charging operations do not cause an absence of battery power.	
178	There are instruments to show the rate of charge.	
179	Cable runs between the fire alarm annunciator and fire detecting or fire alarm zones must be as direct as practicable and, where practicable, are not be in staterooms, lockers, or other enclosed spaces in order to reduce the risk of dam Communications and alarm equipment: Each connection box is constructed in accordance with Type 4 or 4X of NEMA 250; or IP 56 of IEC 60529. age by a localized fire or other cause.	
180	Communications and alarm equipment: Each connection box is constructed in accordance with Type 4 or 4X of NEMA 250; or IP 56 of IEC 60529.	
181	There are at least two sources of power for the electrical equipment of each fire detecting and alarm system.	
182	The capacity of each branch circuit providing power to a fire detection or alarm system is not be less than 125 percent of the maximum load.	

Number	Item	Y/N/NA
183	The emergency power source for the general emergency alarm system meets the requirements of IMO SOLAS 74 Regulation II-1/42 or II-1/43, as applicable.	
184	If the general emergency alarm system is the only load supplied by the general emergency alarm system battery or batteries, the battery or batteries must have an enclosed fused switch or circuit breaker that has a means of locking.	
185	The fused switched or circuit breaker must be outside of, and next to the battery room or battery locker, and the capacity of the fuses or circuit breaker must be at least 200 percent of the connected load.	
186	If the general emergency alarm system is supplied from an emergency or interior communication switchboard, or if duplicate general alarm batteries supply other loads, there is a fused switch or circuit breaker supplying the general emergency alarm system that has a means of locking.	
187	Where the general emergency alarm signal cannot be heard over the background noise, there is a red-flashing light or rotating beacon, in addition to the general emergency alarm signal.	
188	Each contact maker has normally open contacts and constructed in accordance with Type 4 or 4X of NEMA 250 or IP 56 of IEC 60529.	
189	Each general emergency alarm signal is electrically-operated bell, klaxon, or other warning device capable of producing a signal or tone distinct from any other audible signal on the vessel sound level of not less than 80 dB(A) measured at 10 feet on the axis; and at least 10 dB(A) measured at 10 feet on the axis, above the background noise level when the vessel is underway in moderate weather unless flashing red lights are used.	
190	Each cable entrance to an emergency alarm signal or distribution fitting must be made watertight by a terminal or stuffing tube.	
191	Each distribution panel must: watertight and need a tool to be opened.	
192	Each overcurrent protection device causes as wide a differential as possible between the rating of the branch circuit overcurrent protection device and that of the feeder overcurrent protection device.	
Overcurrent Protection		
193	The capacity of the feeder overcurrent device must be as near practicable to 200 percent of the load supplied. The capacity of a branch circuit overcurrent device must not be higher than 50 percent of the capacity of the feeder overcurrent device.	

Number	Item	Y/N/NA
Marking Equipment		
194	Each general emergency alarm system fused switch and distribution panel has a fixed nameplate on the outside of its cover that has a description of its function. The rating of fuses is also shown on the outside of the cover of a fused switch.	
195	Each general alarm contact maker is be marked “GENERAL ALARM” in red letters on a corrosion-resistant plate or on a sign.	
196	A contact maker that operates only the general emergency alarm signal in crew quarters, machinery spaces, and work spaces are marked “CREW ALARM”.	
197	Each general emergency alarm system distribution panel has a directory attached to the inside of its cover giving the designation of each circuit, the area supplied by each circuit, and the rating of each circuit fuse.	